Sensor Torch Based Adaptive Intelligent Control for Circumferential Welding of Pipes

SBIR Contracts: N65538-06-M-0100 and N00024-08-C-4111

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Objectives

Provide systems for

- Manual welding of pipes with guaranteed full penetration by welders with minimal skills for up to 5/36 inch wall on square butt joint –Phase II Base Project
- Orbital welding of pipes with guaranteed full penetration for (roughly prepared) square butt joints for thicker wall-Phase II Option Project

Method: Adaptive Sensing and Control

- Sense the weld penetration;
- Switch the current to the base level after the full penetration is confirmed.

- Full penetration: guaranteed;
- Burn-through: WILL NOT OCCUR before the current is switched to the base level after the full penetration is achieved.

- Why Adaptive and Can Be Used for Manual Operation ?

KEY: Sensor

A durable sensor which is reliable and can be carried by welders: welding torch

Technical Approach

- Measure the depth of the weld pool surface to determine the degree of the weld penetration;

- Why?

(1) Skilled welders can observe the shape of the weld pool surface and use the observed information for penetration control;

(2) Burn-through can only happen when the depth of the weld pool increases to certain level.

SBIR Projects

- Phase I: Demonstrate the feasibility for manual operation for 3.6 mm (5/36”) wall thickness using a manual torch;
- State Match Project: to develop a compact controls system;
- Phase II:

  (1) Develop the control system which works for manual and automated operations;

  (2) Demonstrate at shipyards.

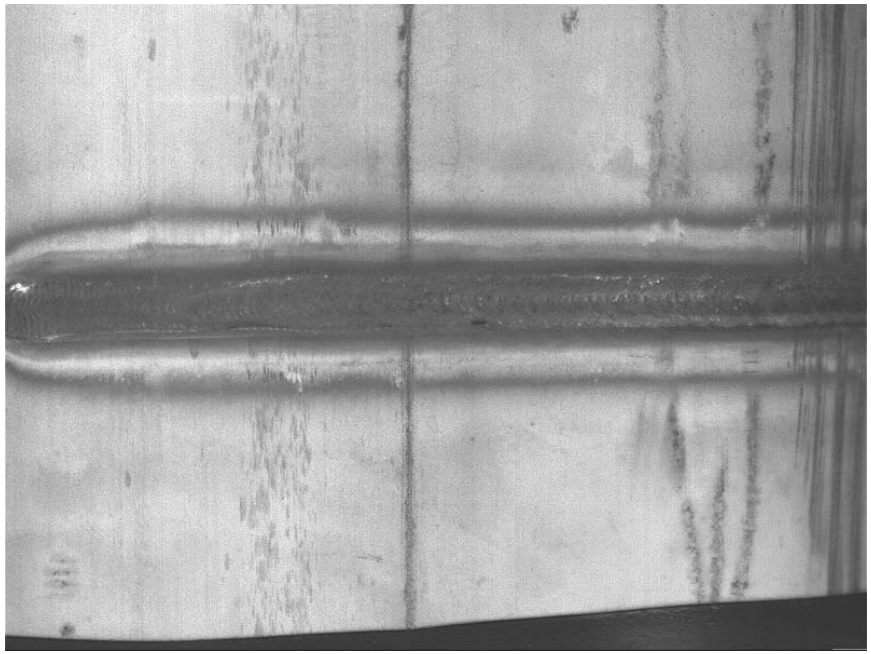
- Partners: Ingalls, Avondale (manual operation)
  Newport News (automated operation)
  Magnatech (integrates the control system in their pipe welding systems, commercialization, marketing)

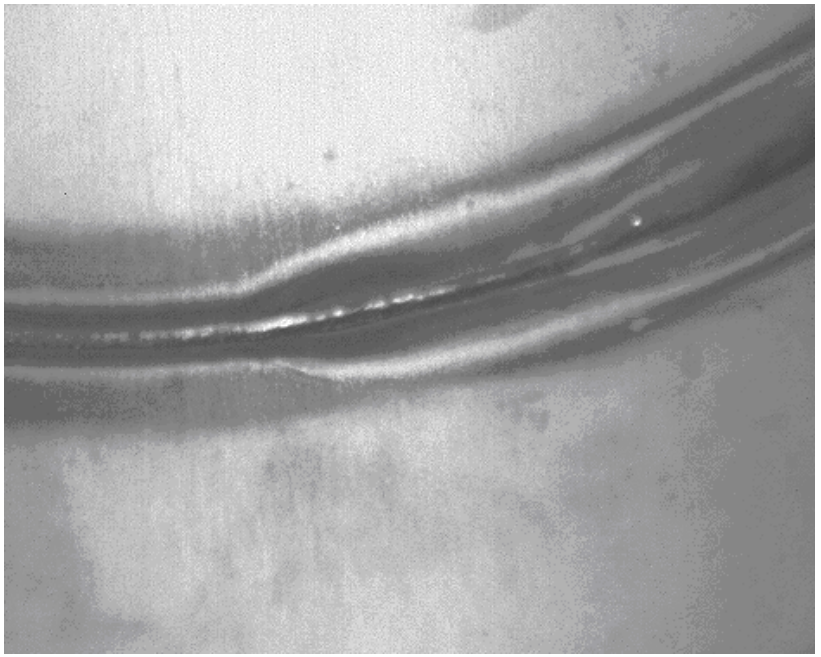
Phase I System

- Plasma System: a CC Power supply, a pilot arc (10 A CC) power supply, a plasma torch;
- Control System: voltage/current sensors, a laptop with data acquisition and analog output, isolation circuits, LabView;
- Welder: YuMing Zhang.

Phase I System Orbital Experiment

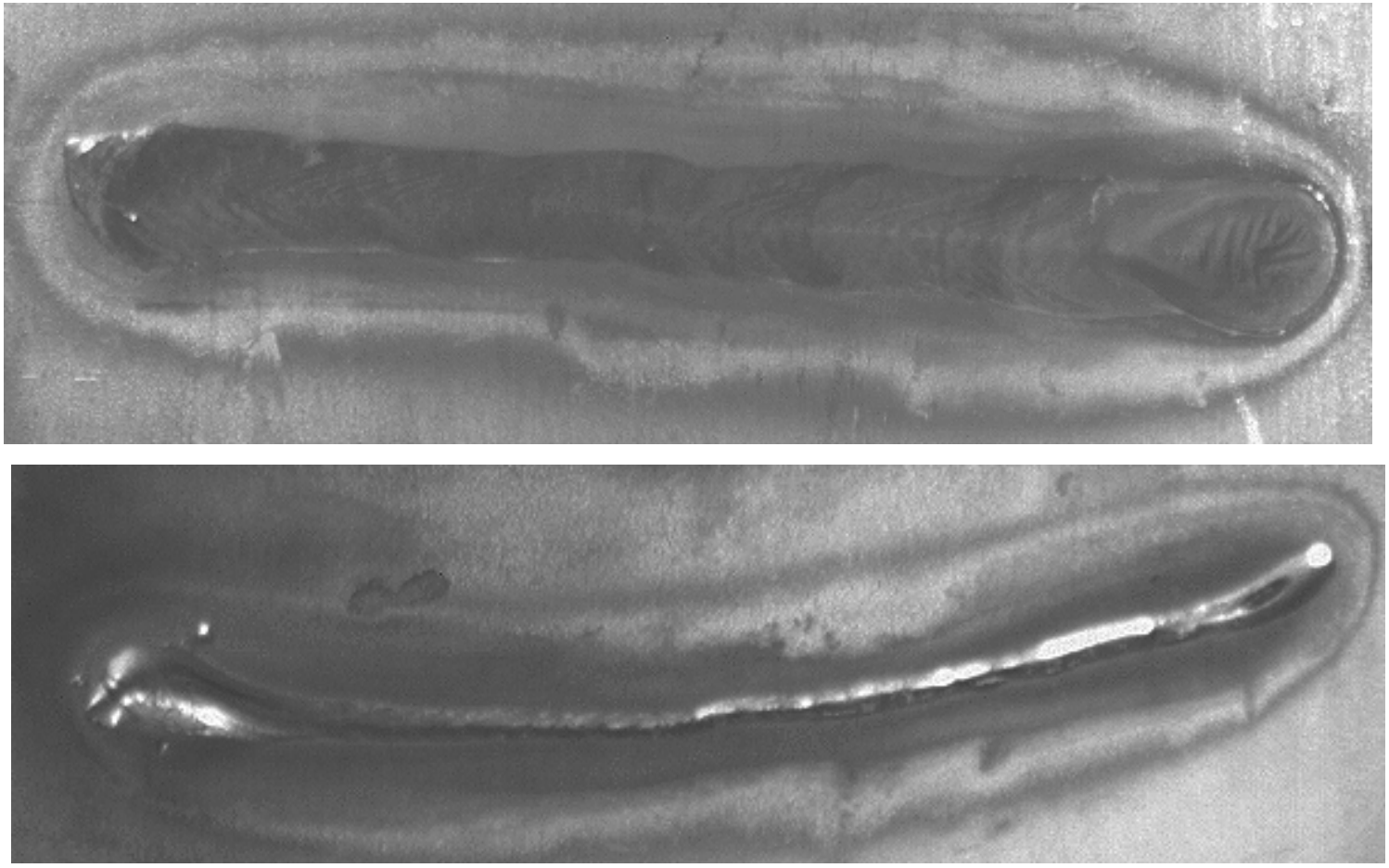
3 mm/s, 97 seconds from 12 o’clock to 6 o’clock





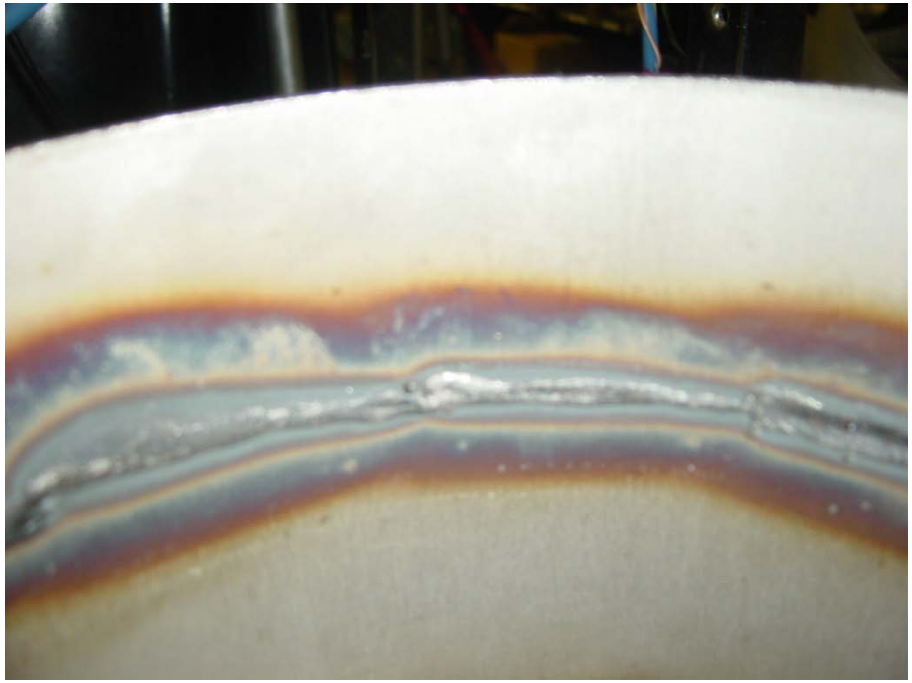
First Manual Experiment: Bead-On-Pipe

25 seconds from 12 o'clock to 1.5 o'clock approximately
(approximately the same speed as in the orbital experiment)

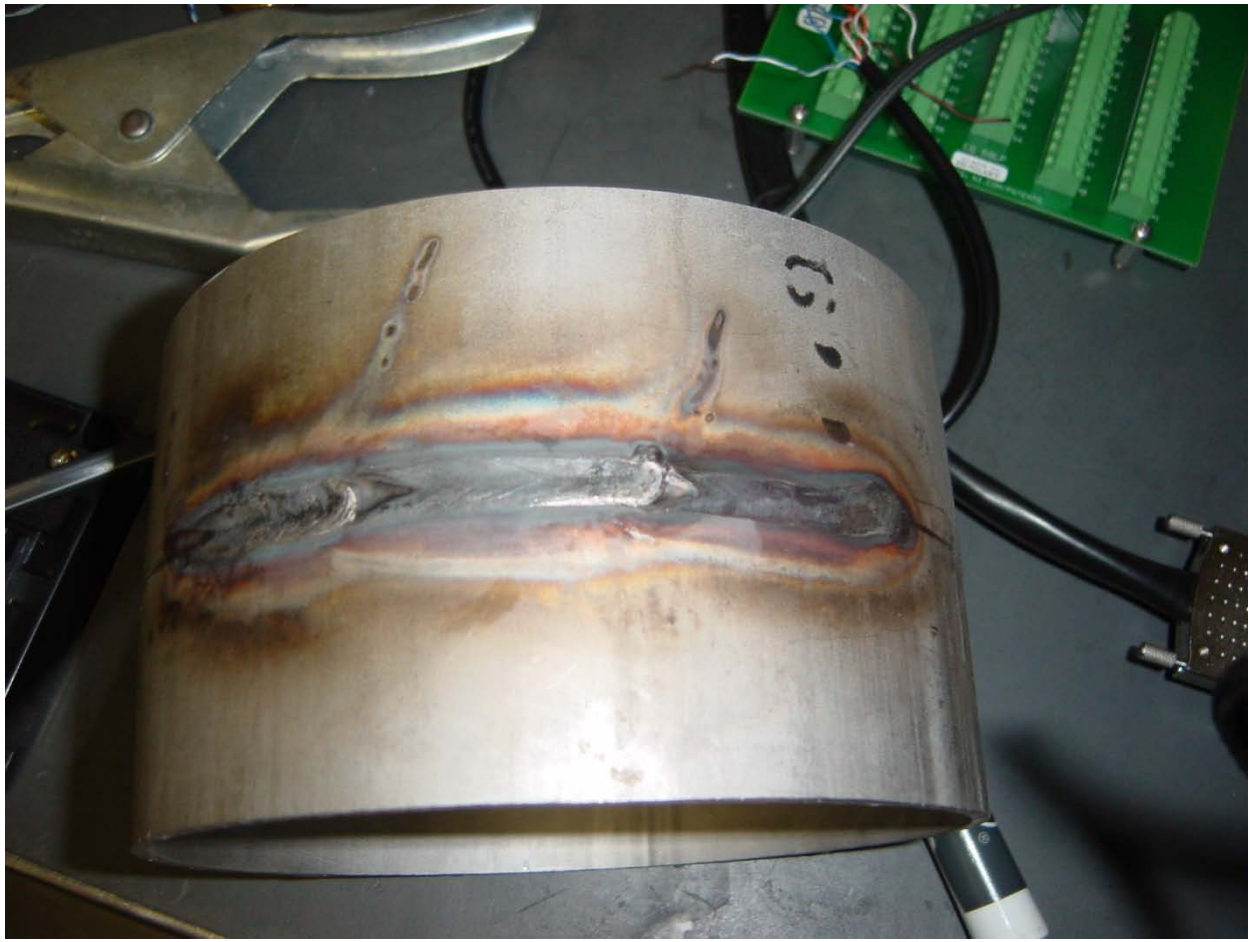


Three Segments Manually Made
12 o'clock to 3 o'clock.

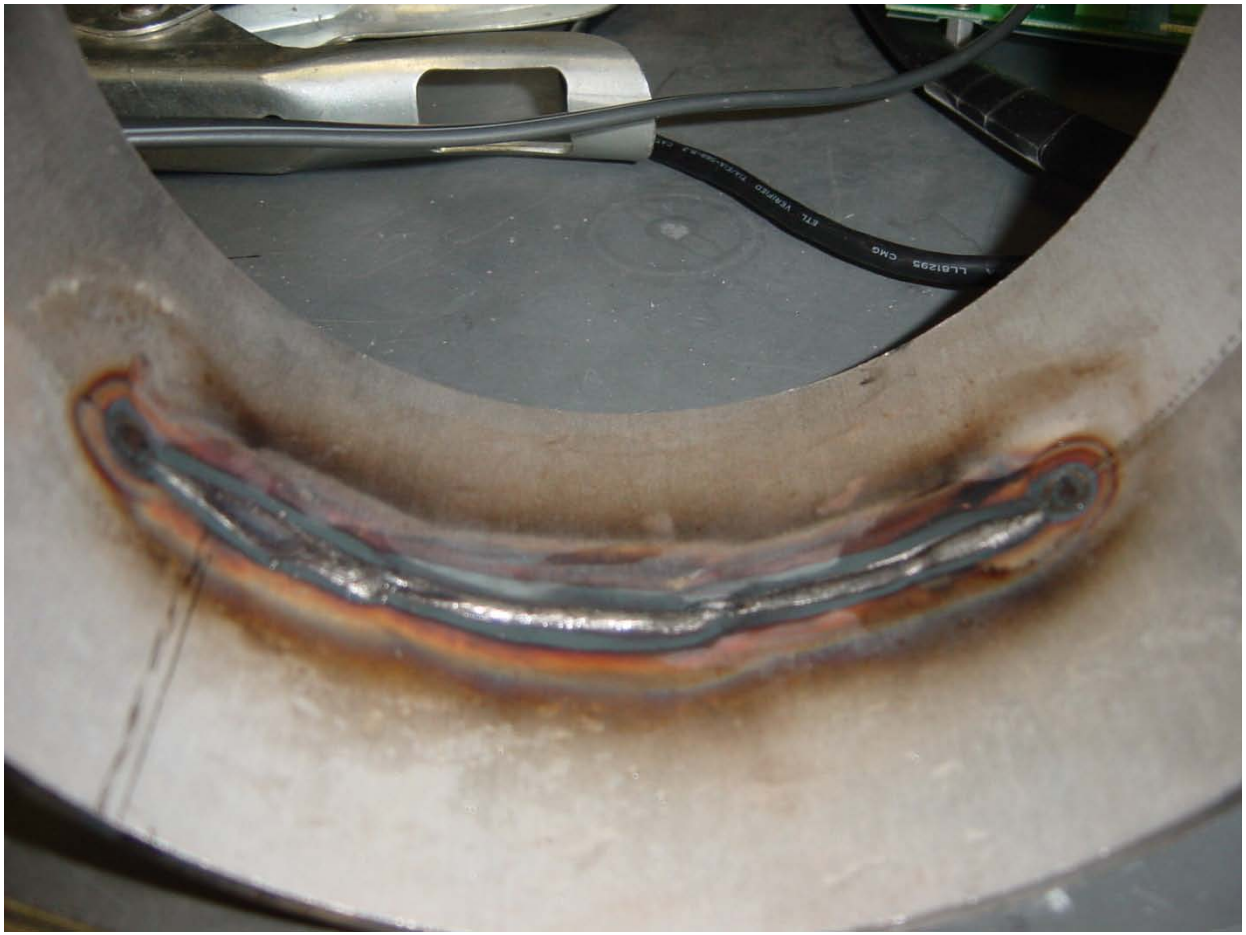
Connected Segments Manually Made
11 o'clock to 3 o'clock



Manual Square Butt Welding Experiment



Manual Square Butt Welding Experiment



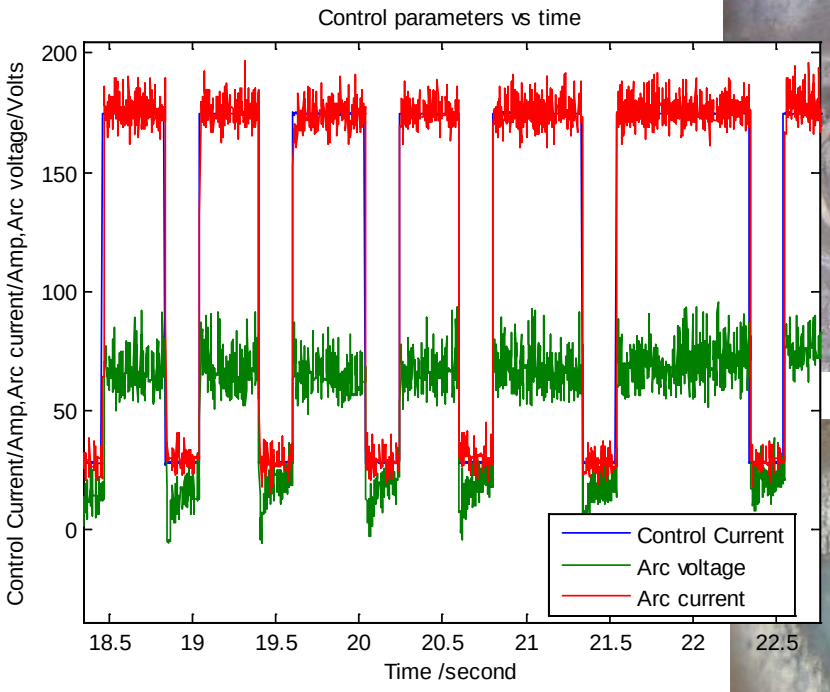
Cross Section of Manual Weld

Phase II Preliminary Prototype System Developed

Human-Machine Interface for Inputting Material, Wall Thickness, and Weld Pool Depth

Phase II Preliminary Prototype System

Preliminary Testing on Mild Steel Pipe



Phase II Demonstration Application Suggestions for feasible biggest payoff applications

Pipe size (diameter and thickness)?

Material (alloy material specifications and grades)?

Gap tolerance? (keep in mind you use square butt joints)

Visual inspection and NDT specifications/requirements

Qualification requirements